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ON LATENT IMAGE FADING IN ILFORD K.0 AND K.2 EMULSIONS

by
E. V. Benton

U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY

SAN FRANCISCO 24, CALIFORNIA

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Eugene P. Cooper
Eugene P. Cooper
Scientific Director

E. B. Roth
E.B. Roth, CAPT USN
Commanding Officer and Director

ABSTRACT

Fading in Ilford K.0 and K.2 emulsions has been investigated at +20°C and -20°C. Track segments with rates of energy loss from 0.6 to 1.8 Mev/micron were used. K.0 and K.2 emulsions stored for 30 days at -20°C showed no evidence of fading. After a 30-day fading period, K.2 emulsion stored at +20°C and at 50 percent relative humidity showed less than 10 percent fading. K.0 emulsion stored at +20°C and at 50 percent relative humidity showed severe fading. This is illustrated by curves of grain density versus residual range for 2-, 6-, 13-, and 30-day fading periods.

SUMMARY

The Problem

To determine the rate of latent image fading in Ilford K.0 and K.2 thick photographic emulsion plates. Grain densities of charged particle tracks developed immediately after exposure are compared with grain densities of tracks which have faded over different periods of time.

The Findings

Grain density of charged particle tracks in K.0 emulsion stored at +20°C and at 50 percent relative humidity for one week after exposure decreases to 50 percent. K.2 emulsion stored for 30 days at +20°C and at 50 percent relative humidity shows less than 10 percent fading. K.0, K.2 emulsion stored for 30 days at -20°C show no measurable fading.

INTRODUCTION

A charged particle track can yield information with regard to energy, rate of energy loss, charge, and mass of the particle which produced it. This information is contained in the various track parameters such as: residual range, mean gap length, mean blob length, track width, track taper, delta-ray density, and scattering.[1,2] It is a well-known fact that emulsion grains which have been rendered developable by the passage of a charged particle through them may, in time, lose this property. This process is usually referred to as the "fading of the latent image" and is a function of time, temperature, relative humidity, and the restricted energy loss of the charged particle.[3,4] As fading takes place, the amount of information contained in a track decreases. This decrease in the available information may seriously affect the results of the experiment. Thus, the rate of latent image fading is an important property of an emulsion and one that must be known prior to experiment.

Insensitive Ilford emulsions K.0, K minus 1, and K minus 2 were used in this Laboratory for the purpose of measuring the rates of energy loss of multiply charged particles. Experiments were conducted using both artificially and naturally accelerated ions. The time between exposure and processing is a variable that often cannot be controlled. This is especially true in the case of balloon type cosmic-ray exposures. The emulsion stack may descend into a rather inaccessible area where it takes days for recovery; therefore, a period of 2 weeks between exposure and processing is not uncommon.

Because of the absence of information on latent image fading in the insensitive Ilford emulsions, an experiment was undertaken to establish the magnitude of the rate of this process.

DESCRIPTION OF EXPERIMENT

A set of Ilford K.0 emulsions, all from the same batch, and a set of K.2 emulsions, also from a single batch, were used in this experiment. The single-batch requirement was necessary because emulsions differ slightly in sensitivity from batch to batch. Glass-backed emulsions, 1 x 3 in., with a thickness of 100 microns, were used. This thickness sufficed since the ions entered at a shallow angle with respect to the surface of emulsion and had only a small range (approximately 155 microns).

Previous to exposure the plates were stored at room temperature and in their original wrapping in an emulsion storage cave at the University of California.

Exposure

The exposure was made at the Heavy Ion Linear Accelerator (HILAC), Lawrence Radiation Laboratory, Berkeley, using a monoenergetic beam of O^{16} ions (10.4 $\pm$ 0.2 Mev/nucleon). The emulsions were placed in a holder at the end of an evacuated beam tube. The plates were positioned in such a way that the incoming ions entered the emulsion with a dip angle of about 5 deg. The correct exposure was determined by the use of Ilford C.2 plates, 25 microns in thickness, that were included as a monitor with the other emulsions. After each exposure the C.2 plates were immediately developed and scanned to determine the adequacy of the number of tracks and their distribution over the area of the plate.

Storage

Less than 15 minutes after exposure, a K.2 and a K.0 plate were processed. These plates served as controls. The remaining plates were divided into two groups. Group 1 consisted of a set of K.2 and K.0 plates that were stored at +20°C and constant humidity (50 percent),

while Group 2 was wrapped in heavy black paper and polyethylene and was stored at -20°C in a deep freeze.

The plates were allowed to fade for periods of 2, 6, 13 and 30 days. At the end of each period, they were taken from storage, unwrapped, and allowed to come to equilibrium with surroundings; then they were processed.

Processing

The processing was kept as constant as possible from batch to batch. The ingredients used were as follows:

a. Bristol Developer:

Distilled water	1000 c.c.
Sodium sulfide (anhydrous)	7.2 gms
Sodium bisulfide	1.0 gm
Potassium bromide (10 percent solution)	8.7 c.c.
Amidol	3.25 gms

b. Short Stop:

Distilled water	1000 c.c.
Acetic acid (glacial)	2 c.c.

c. Fixer:

Distilled water	1000 c.c.
Sodium thiosulfate	300 gms
Sodium bisulfide	22.5 gms

d. Drying Solution:

1. 50 percent ethyl alcohol, 45 percent distilled water, 5 percent glycerin
2. 75 percent ethyl alcohol, 20 percent distilled water, 5 percent glycerin
3. 95 percent ethyl alcohol, 5 percent glycerin

The processing times and temperatures are as follows:

a.	Water presoak	5°C	50 min
b.	Developer presoak	5°C	50 min
c.	Warm development (1 to 1 dilution with distilled water)	23°C	60 min

d.	Short stop	10°C	50 min
e.	Fixer	10°C	clearing time plus 50 percent
f.	Washing	10°C	until passes permanganate test
g.	Drying	10°C	three steps 30 min each

After the last step of alcohol treatment was completed, the plates were spread out in air, blotted with filter paper, and allowed to dry at room temperature.*

MEASUREMENTS

Method

The photomicrographic technique for measuring grain densities of particle tracks in electron insensitive emulsions has been previously described.[5] The estimate of grain density g_1 is obtained from photomicrographic measurement of the mean gap length according to the formula

$$N(\ell) = N_o \, e^{-\ell/\bar{\ell}}$$

where

$N(\ell)$ = the number of gaps greater than some ℓ

N_o = total number of gaps

$\bar{\ell}$ = $1/g_1$ = the mean gap length

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* Private communication to the author from C. Cole, University of California Lawrence Radiation Laboratory (1961).

If the above distribution function is plotted on a semi-logarithmic graph, then the slope of the line has a very simple significance--it is equal to $1/g_1$. The exponential nature of the gap length distribution offers certain practical advantages to this technique: (1) Only gaps over a certain length have to be measured and a least squares solution to the experimental points can be extrapolated to obtain N_o. (2) If all gaps are either increased or decreased a given amount, in the case of different observers who read consistently longer or shorter gaps, the slope of the distribution remains unchanged.[1,6]

During the course of this investigation, the exponential nature of the gap length distribution was verified for Ilford K.0, K minus 1, and K minus 2 emulsions using Ne^{20}, O^{16}, and C^{12} ions with rates of energy loss varying from 0.35 to 2.35 Mev/micron (Fig. 1). In Fig. 2 is shown a typical set of measurements for K minus 1 emulsion for Ne^{20}, O^{16}, C^{12} ions with $\beta = 0.14$. The measurements represent an average of one hundred sections of tracks, each 10 microns in length.

Selection of Tracks

Tracks to be measured were checked for correct range and dip angle in emulsion. Only tracks that showed little or no multiple scattering were used. Measurements were restricted to tracks in the center of emulsion. As pointed out by Leide, there are reasons to expect greater fading at the surface of the emulsion than in the interior.[3,4] We have evidence suggesting that this is indeed the case.* Because of the short range of the ions used, it was not possible to eliminate this surface fading effect from our measurements. However, measurements near the end of the residual range, where the track is deepest in emulsion, are least affected by this phenomenon.

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* To be published in 1963 by the author.

RESULTS

Typical tracks of O^{16} ions in K.0 emulsion used in this experiment are shown in Fig. 3. The ions traverse the emulsion from left to right. The tracks from head to foot of the figure are:

(A) control

(B) 2 days' fading at $+20^{\circ}C$

(C) 6 days' fading at $+20^{\circ}C$

(D) 13 days' fading at $+20^{\circ}C$

(E) 30 days' fading at $+20^{\circ}C$

(F) 30 days' fading at $-20^{\circ}C$

Figure 4 shows a corresponding series of faded tracks in K.2 emulsion. As can be seen in a comparison of B to A in Fig. 3, fading of grains in K.0 emulsion can be visually detected after two days. From then on increased fading is quite apparent and is evidenced by the increase in length and density of gaps in the track. In time an opaque track develops a structure; e.g., the increase in grain density toward the end of residual range in E may be observed in Fig. 3. The increase in grain density corresponds to the increase in the rate of energy loss of a particle as its velocity decreases.

Quantitative information on fading in K.0 emulsion is given in Fig. 5. The grain density per micron is plotted as a function of residual range and period of fading. Data on the control tracks correspond to a saturation value of 6-7 grains/micron which is in good agreement with the Patrick-Barkas data for K.5 emulsion.[7] The agreement is significant because all Ilford K series emulsions have approximately the same mean grain diameter of 0.20 microns.[8] No fading could be detected in K.0 plate that was kept for 30 days at $-20^{\circ}C$.

Measurements on tracks in K.2 emulsion indicate that, for rates of energy loss used in this experiment, latent image fading is a comparatively slow process. The grain density of tracks that were allowed to fade for 30 days at room temperature and 50 percent relative humidity differs by less than 10 percent from the grain density of control tracks and therefore is the same within the accuracy of experiment. Tracks that were stored for 30 days at -20°C are indistinguishable from the control tracks.

DISCUSSION

Figure 5 shows that the degree of latent image fading determines the appearance of a charged particle track in a K.0 emulsion. Depending on ionization and the extent of fading, grain density of a track can vary between 0 and 6 grains/micron. A track of a stopping oxygen ion in a K.0 emulsion that was faded for a period of 2 weeks looks identical to an oxygen ion track in a less sensitive K minus 1 emulsion that was processed immediately upon exposure. In this manner, latent image fading can be used to control the apparent sensitivity of an emulsion.

All measurements discussed were performed twice or more by different observers. The error bars in Figs. 2 and 5 correspond to errors arising from the statistical fluctuations in the gap length distribution. The errors introduced by the subjectivity of the readers were almost always greater than the statistical errors. It was found that the reader errors were a function of g_1 and increased as g_1 increased. For g_1 of the order of 1 grain/micron the measurement is accurate to better than 10 percent; for $g_1 \approx 7$ the errors can be as large as 25 percent.

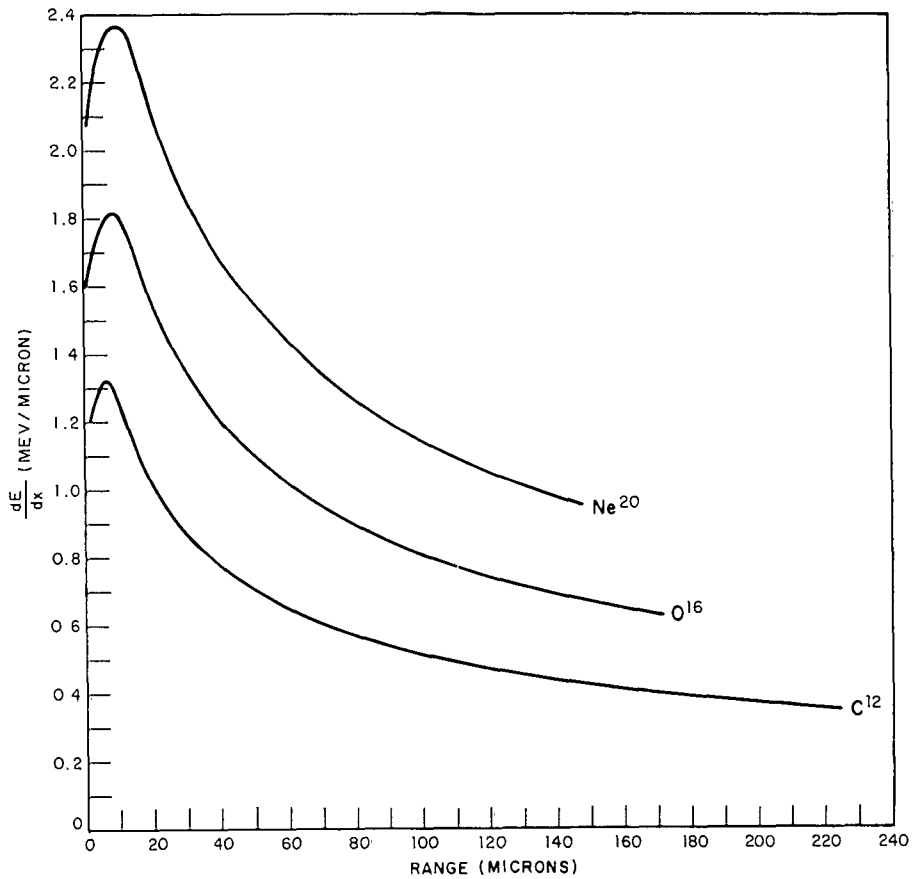


Fig. 1 The rate of energy loss as a function of residual range. Reproduced from Heckman (1959)[9] with the permission of the author.

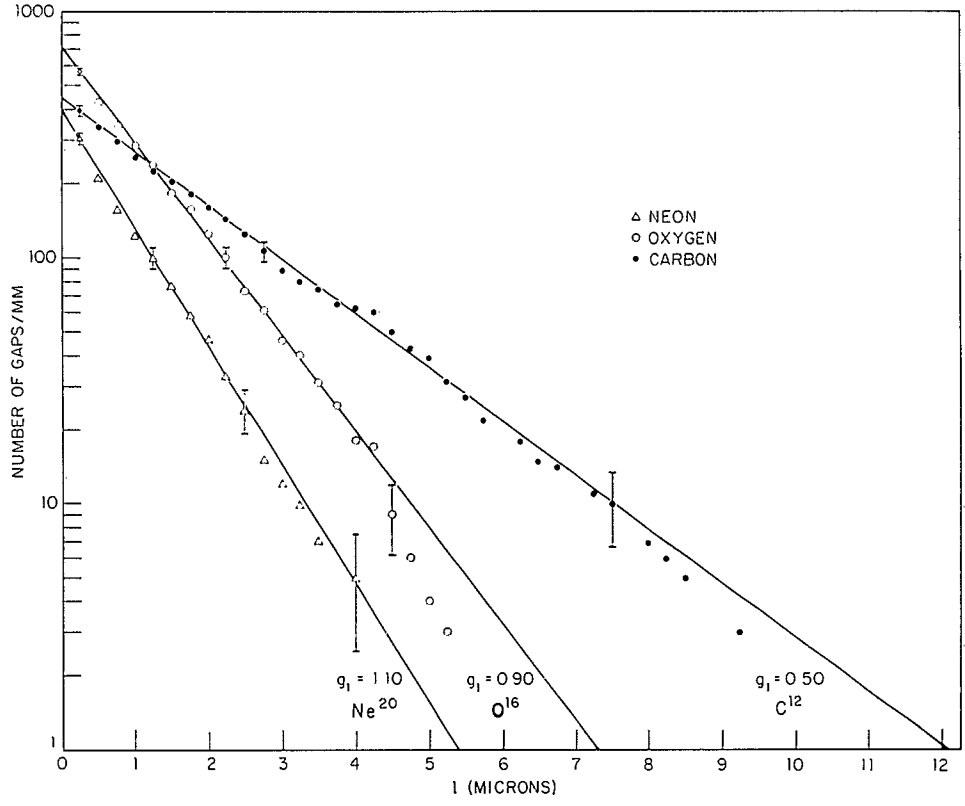


Fig. 2 Variation of the number of gaps of length equal to or greater than ℓ with gap length ℓ, for particles with rates of energy loss 1.0, 0.65, and 0.40 Mev/micron.

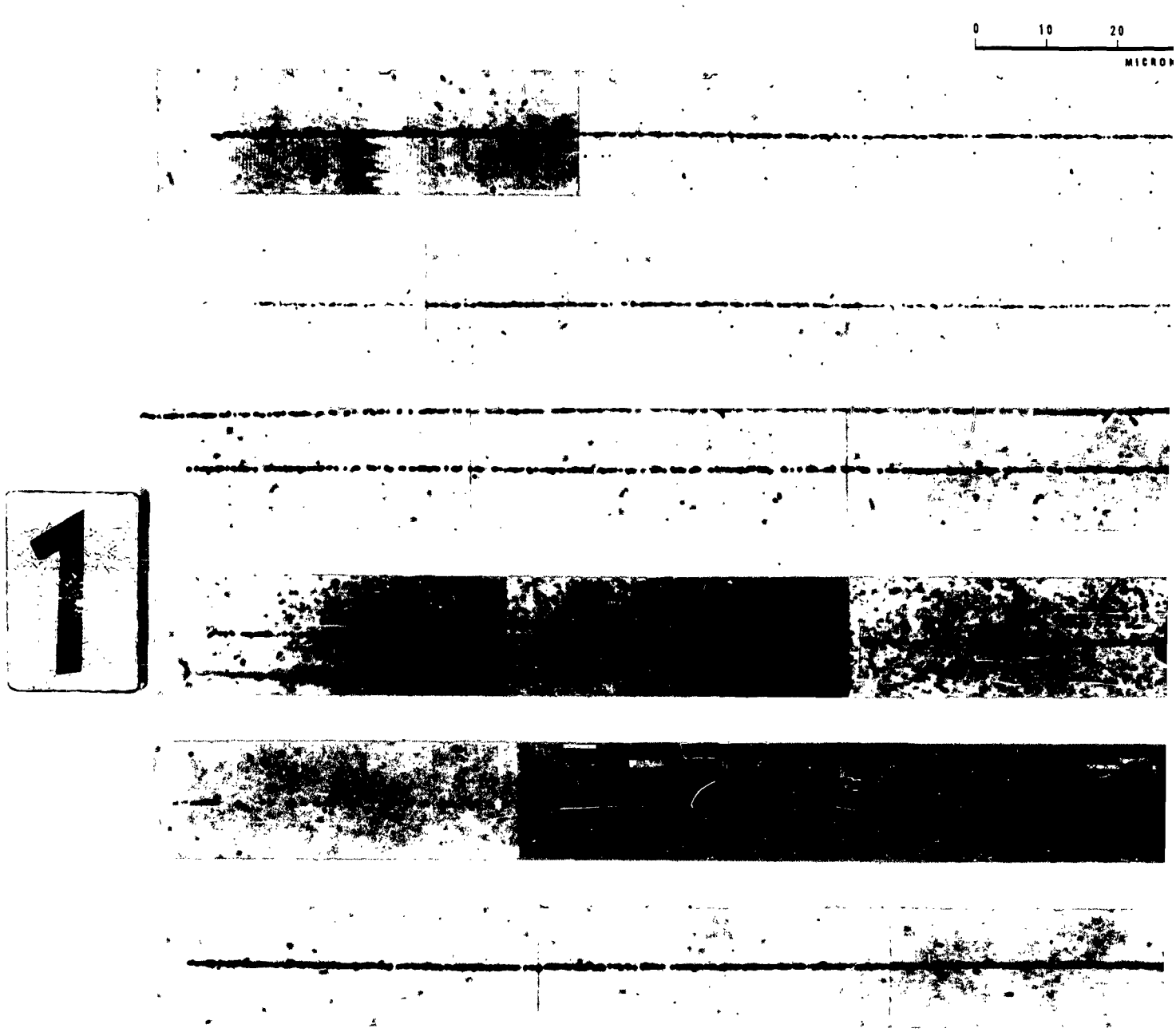
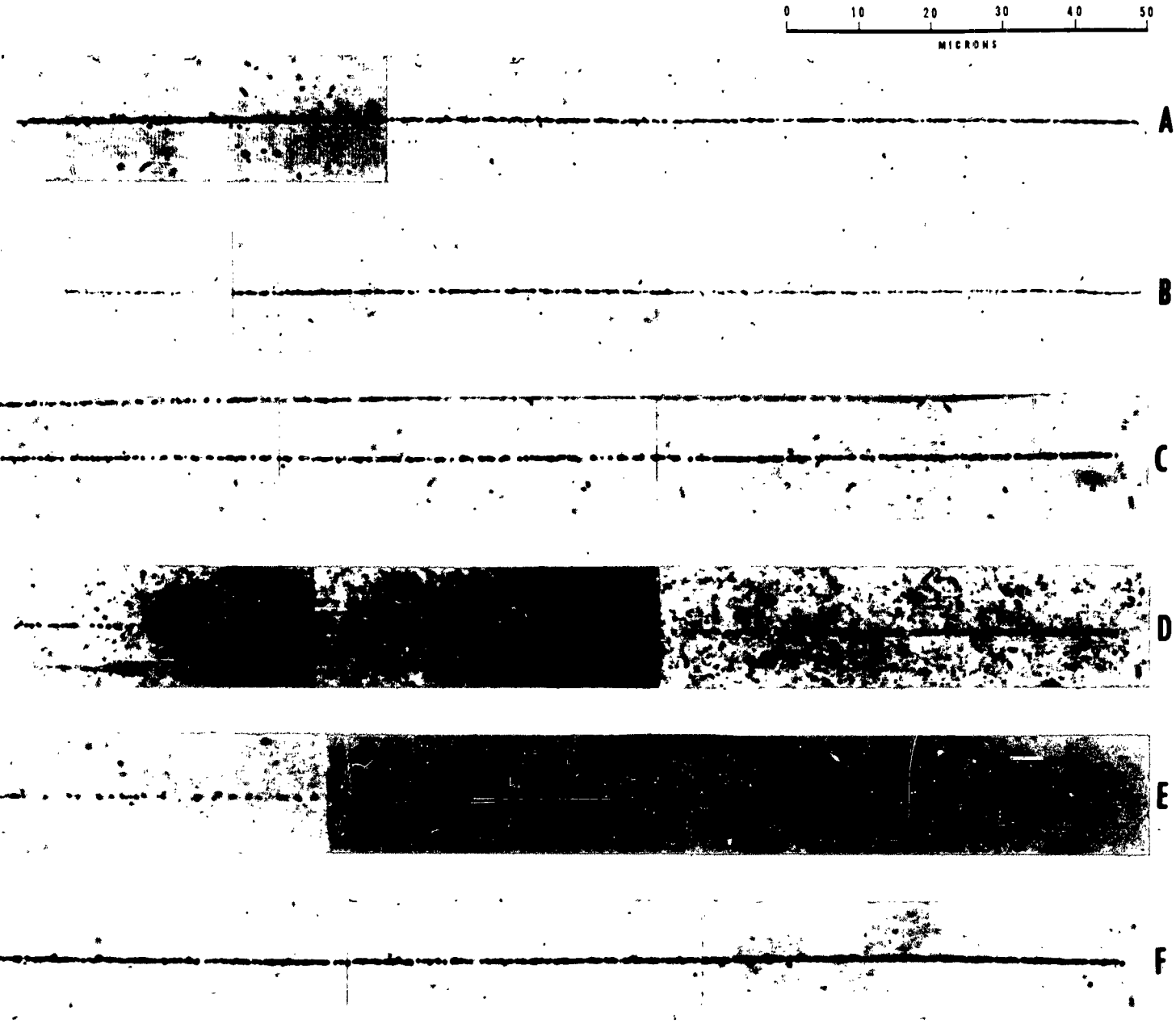


Fig. 3 Photomicrographs of 160-Mev oxygen ions in Ilford K.0 nuclear-track emulsion. traverse the emulsion from left to right. Tracks from head to foot of the figure are (B) 2 days' fading at +20°C, (C) 6 days' fading at +20°C, (D) 13 days'fading at +20°C fading at +20°C, (F) 30 days' fading at -20°C.



3 Photomicrographs of 160-Mev oxygen ions in Ilford K.0 nuclear-track emulsion. The particles rse the emulsion from left to right. Tracks from head to foot of the figure are: (A) control, days' fading at +20°C, (C) 6 days' fading at +20°C, (D) 13 days' fading at +20°C, (E) 30 days' g at +20°C, (F) 30 days' fading at -20°C.

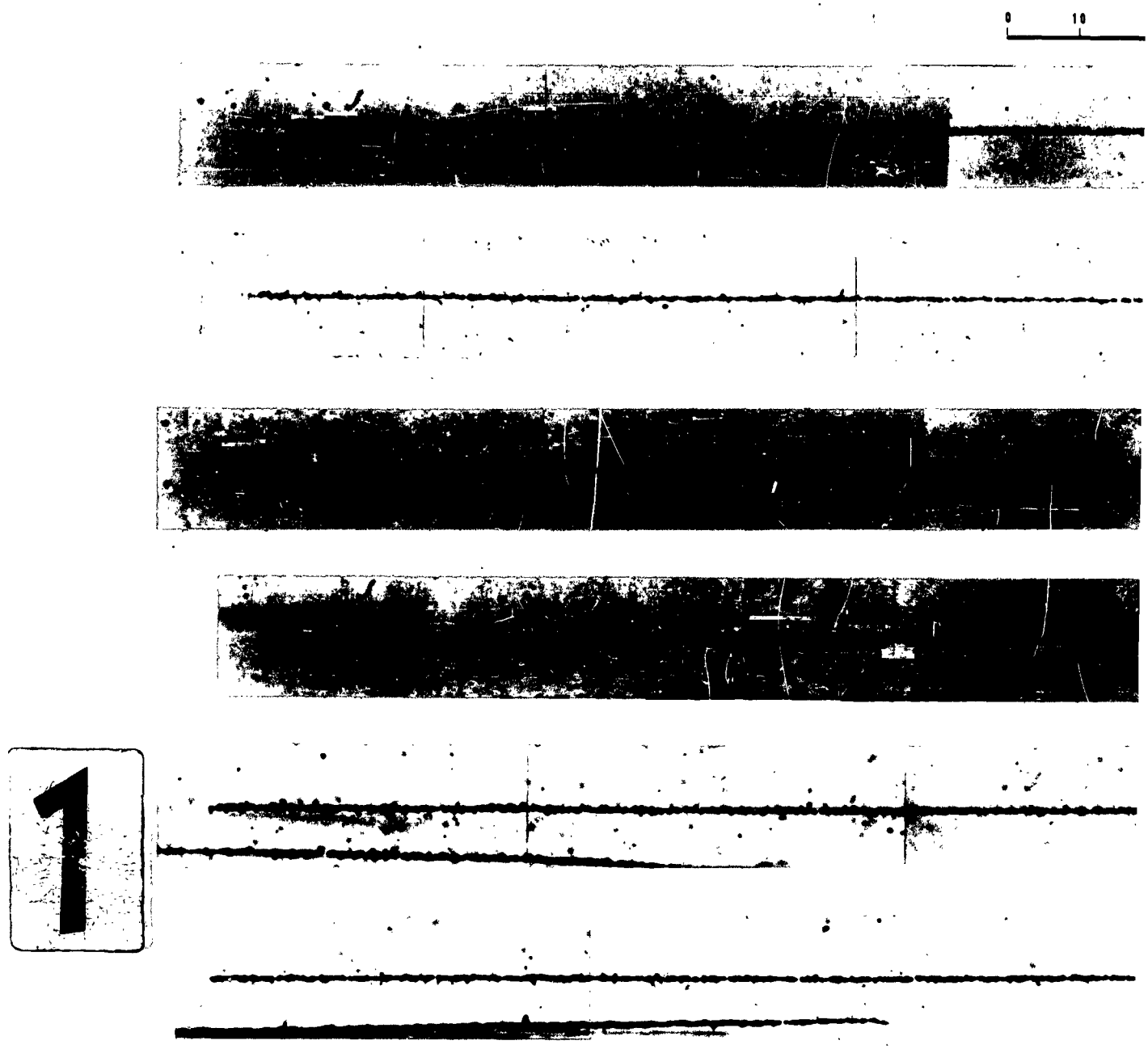
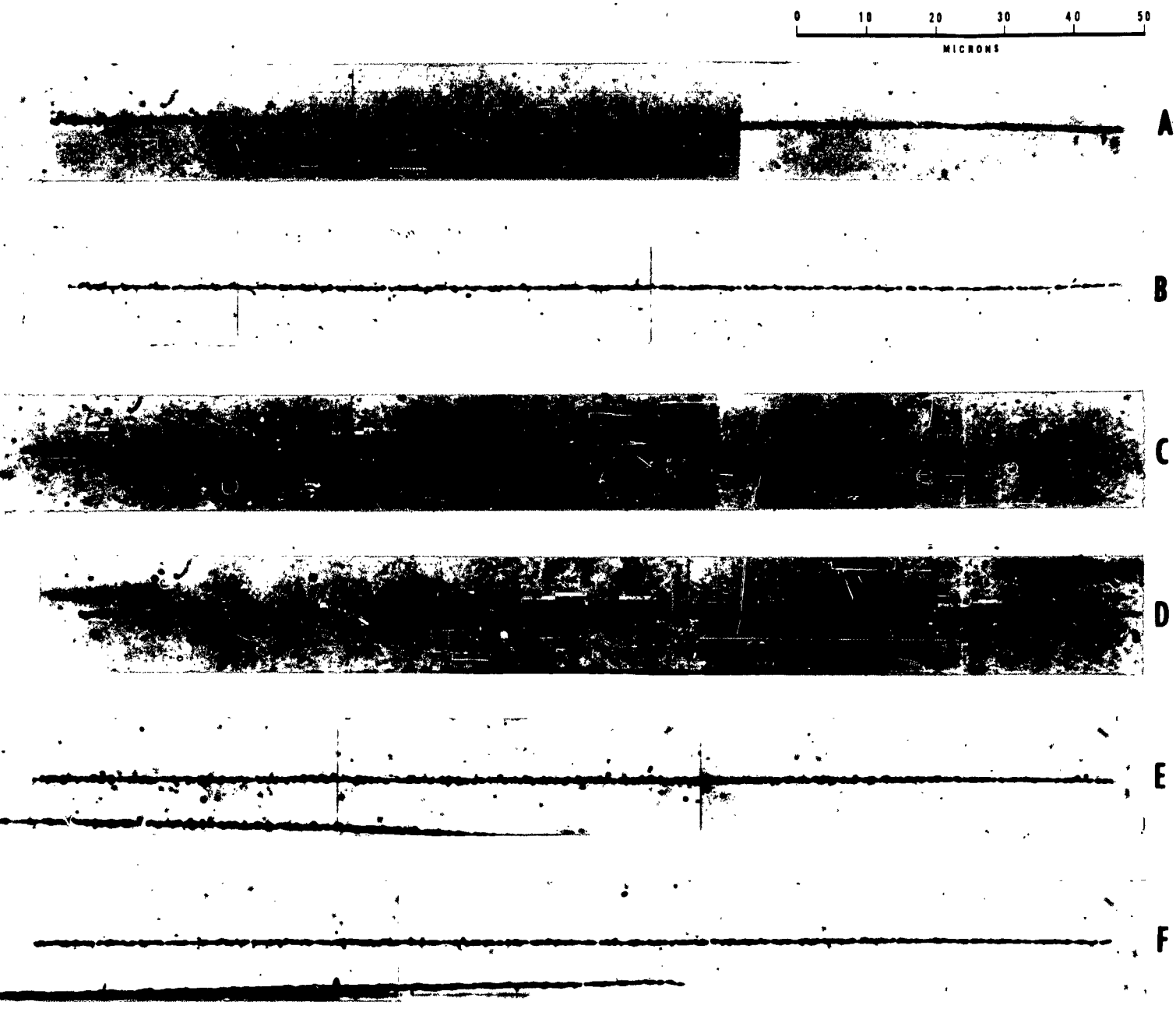


Fig. 4 Photomicrographs of stopping 160-Mev oxygen ion tracks in electron-sensit
The particles traverse the emulsion from left to right. Tracks from head to foot
(A) control, (B) 2 days' fading at +20°C, (C) 6 days' fading at +20°C, (D) 13 day
(E) 30 days' fading at +20°C, (F) 30 days' fading at -20°C.



. 4 Photomicrographs of stopping 160-Mev oxygen ion tracks in electron-sensitive K.2 emulsion. particles traverse the emulsion from left to right. Tracks from head to foot of the figure are: control, (B) 2 days' fading at +20°C, (C) 6 days' fading at +20°C, (D) 13 days' fading at +20°C, 30 days' fading at +20°C, (F) 30 days' fading at -20°C.

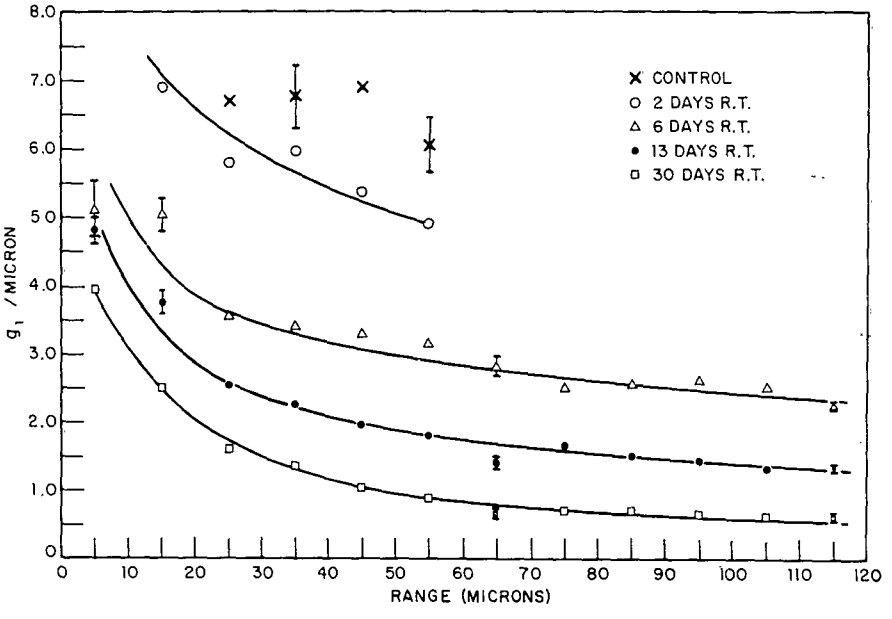


Fig. 5 The observed grain density of "control" and faded tracks of stopping O^{16} ions in Ilford K.0 emulsion versus residual range.

REFERENCES

1. C. F. Powell, P. H. Fowler, and D. H. Perkins, The Study of Elementary Particles by the Photographic Method. Pergamon Press, 1959, p. 101.

2. W. H. Barkas, "An Information Content of Particle Tracks." Phys. Rev. 124, 847 (1961).

3. Göran Leide, "An Investigation on Latent Image Fading in Ilford G-5 Emulsions." Arkiv för Fysik 11, 329 (1957).

4. Göran Leide, "An Investigation on Latent Image Fading in Ilford K-5 Emulsions." Arkiv för Fysik 22, 147 (1962).

5. E. V. Benton, "Photomicrographic Technique for Measuring Grain Densities of Highly Ionized Particle Tracks in Nuclear Emulsions." USNRDL-TR-591 (1962).

6. K. I. Alekceva, T. L. Gabuniya, G. B. Zhdanov, E. A. Zamchalova, M. N. Sherbakova, M. I. Tretyakova, "Study of Primary Cosmic Radiation at an Altitude of 320 km." Artificial Satellites of the Earth 12, 6 (1962) (in Russian).

7. J. W. Patrick and W. H. Barkas, "The Grain Density of Emulsion Tracks." Nuovo Cimento Suppl. 23, 1 (1962).

8. Ilford Technical Information Sheet Y44.1.

9. H. H. Heckman, B. L. Perkins, W. G. Simon, F. M. Smith, W. H. Barkas, "Range and Energy-Loss Processes of Heavy Ions in Emulsion." UCRL-8763.

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